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ARCSTONE: Calibration of Lunar Spectral Reflectance from Space

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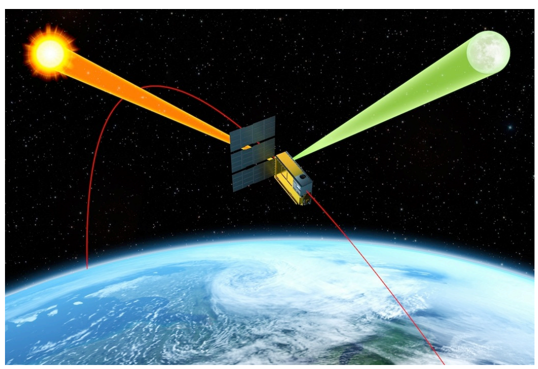
Background: One of the most challenging tasks in remote sensing from space is achieving required instrument calibration accuracy on-orbit. The Moon is considered, theoretically, to be an excellent exoatmospheric calibration source. SeaWiFS was the first spaceborne sensor to make full use of the Moon imaging for on-orbit radiometric performance. The resulting calibration history demonstrated the efficacy of the approach: stability of the top-of-atmosphere radiances over 12 years, derived from the lunar time series, is 0.13%. However, the current accuracy of the Moon as an absolute reference is limited to 5 – 10%. Inadequate accuracy of absolute lunar irradiance values causes mission operators to cite the risk of lunar maneuvers exceeding benefits. ARCSTONE is a mission concept that provides a solution to this challenge. An orbiting spectrometer flying on a small satellite in low Earth orbit (LEO) will provide lunar spectral reflectance with accuracy sufficient to establish an SI-traceable absolute lunar calibration standard for past, current, and future Earth's weather and climate sensors. At the mission time, the ARCSTONE will leverage existing NASA assets by using the TSIS observations - accurate Spectral Solar Irradiance (SSI). The SSI established by the TSIS will be used for SI-traceable and spectral calibration of ARCSTONE instrument on orbit.

Required Observations: The ARCSTONE mission concept is shown in Figure below[2]. Spectral measurements of lunar and solar irradiance are required to retrieve reflectance of the Moon with spectral range from 350 nm to 2300 nm and spectral sampling of 4 nm. The ARCSTONE mission goal is to achieve $< 1.0\% (k = 2)$ absolute accuracy for spectral lunar reflectance. Daily observations over 3 years are needed to cover minimum required libration space.



Mission Impacts: (1) Collaborating with the GSICS community, the ARCSTONE mission will provide the data necessary to establish the international standard for absolute lunar calibration. Improved accuracy of Earth's observations impacts science output directly: the MODIS team has demonstrated calibration impact on land data products, the CLARREO team has established high accuracy requirement for climate change observations from space. (2) The economic impact of establishing highly accurate Earth climate observations is estimated at $\sim$ \$12T over 40 to 60 years[3], (3) Impact on performance of past (SeaWiFS), and current (MODIS, VIIRS), and future Decacal Survey missions – PACE, CLARREO, and ACE.

Technical Readiness: Currently, the ARCSTONE instrument is at TRL3. The instrument breadboard has been assembled, tested, and characterized at NIST in April 2016. Initial flight instrument design is completed. The mission can be ready for launch in 3 years from start date.

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[2]Spacecraft Bus image courtesy of Blue Canyon Technologies.

[3]Cooke et al., "Value of Information for Climate Observing Systems," *Environ. Syst. Decis.*, 12 pp., 2014.